Deliverable H

Prototype III and Customer Feedback

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Introduction

This deliverable, once again, provides an overview of the final changes made to the prototype in preparation for design day. The overview explains the reasoning behind each change and the benefits associated with each modification as well as a figure for displaying each change. This also documents the test cases that the team have conducted and will conduct to determine the durability and reliability of the system. Then explain the results of the tests and what has changed due to the results. Finally, the document explains where the team would have continued to develop if there was more time available before the final deadline or more funds available in the budget.

Software Subsystem

In deliverable G, the basic functionality was achieved by using NodeMCU and a motion sensor. The group focused on improving the user experience and implementing a camera to the over the last week.

The user interface was rebuilt: First, the tabs and images all the printers were removed to improve the aesthetic. They were replaced with a single menu which contained a button for each printer.These buttons are arranged in a real-world order. For example, the bottom “UM2P-01” in the left corner corresponds to the position of the first Ultimaker 2+ 3D printer on the shelf in the Makerspace. For this design design, once the user clicks on a button, the two read-only-text, below, will give feedback immediately. The first blank space will show which printer the user is monitoring and the second blank space will give its state. There is a delay between someone push the button and receive its feedback. However this delay has been deemed acceptable since this prevents the system from detecting a slight motion for a fraction of a second and providing a false reading to the system.

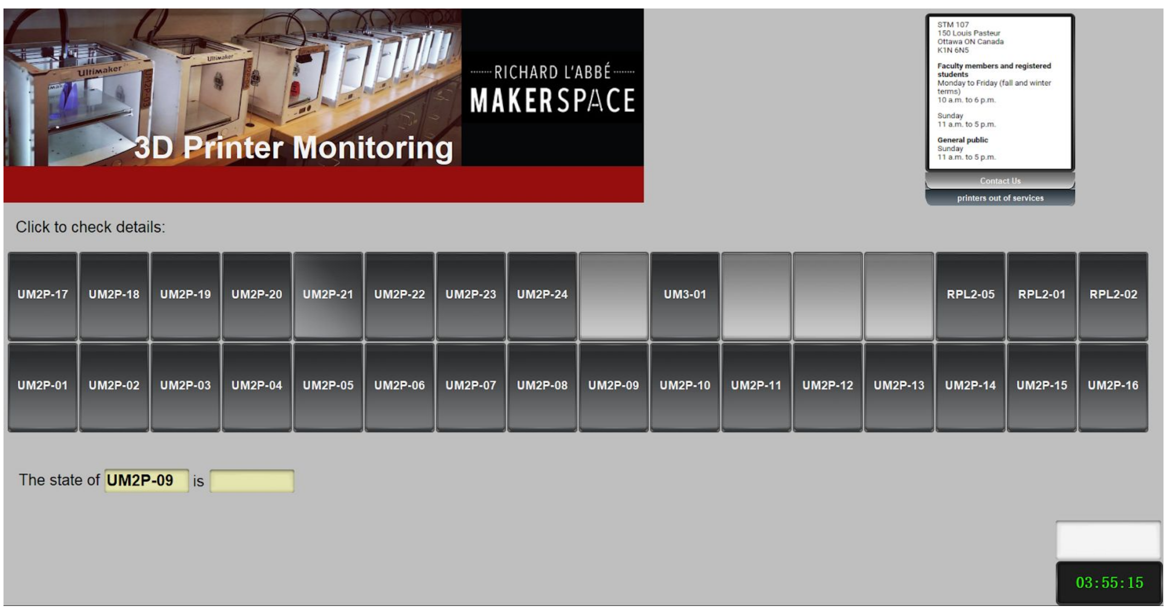

Figure 1: Dashboard screenshot

After extensive testing on camera functionality, the team has decided to abandon it due to several reasons. First, it would take much longer than expected to implement the software and the hardware into the system than the time remaining until the deadline. Secondly, an additional component was needed to make the camera work. This component would overextend the budget, so the group decided it would be better to use the remaining budget to instead improve the fidelity of the prototype with an additional motion sensor.

The group tried to publish the user interface as a web page. However, the Dashboard is not capable of doing so, due to its limited temporary storage space. The built-in function can merely upload the trigger buttons to a local host instead of publishing the whole user interface. During testing, the local host web page behave like a remote controller which is does not address the issues laid out in the problem statement.

Although the software subsystem can be improved in many ways, the current version will be the final version due to time constraints.

Hardware Subsystem

Following ‘Deliverable G’, the team improved the fidelity of the prototype by adding a second motion sensor in order to create a more comprehensive model of the system. This tests the system to a higher degree, since it now handles additional inputs from another source. However, this does not significantly affect the layout of the board, as they both can be soldered to either side of the component, since there are multiple pins that can be used as a ground connection for the motion sensor.

Additionally, the team also decided on a design for properly mounting the motion sensors to the Ultimaker 2+’s. A piece will be printed using the PLA plastic that will slide over the elevated edges on the printer walls. This piece will have a flat surface for its top face which will then be attached to the motion sensor. This design allows for the motion sensor to be removed from the printers easily for maintenance. Plus, the piece is designed specifically for the corners of the printers with the motion sensor pointing to the centre. This way the piece can only be placed on corners, the intended position, and will always face the centre of the motion sensor. However, if the staff move the motion sensor to a position such that it can observe people passing by the printer or working at nearby workstations this would produce false readings for the dashboard to read. To combat this, the members working on the software subsystem are working on applying a range for the motion sensor that would only search through distances, approximately the size of the workspace of an Ultimaker 2+.

In order to keep the motion sensor safe, a new case with similar dimensions is being designed in *Inkscape* to be laser cut from MDF. This material is much better for putting screws into, over the plastic used in 3D printed parts. For MDF, we need not design the parts with pre-cut holes for the screws, they can be inserted where they are needed. On the contrary, printed pieces need pre-printed holes for the screws so that they are not destroyed when the screws are inserted.

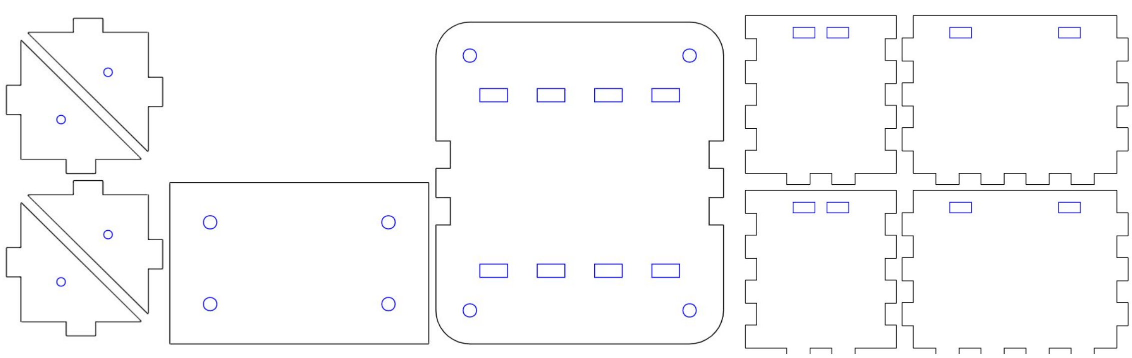

Figure 2: *Vector for Motion Sensor Case*

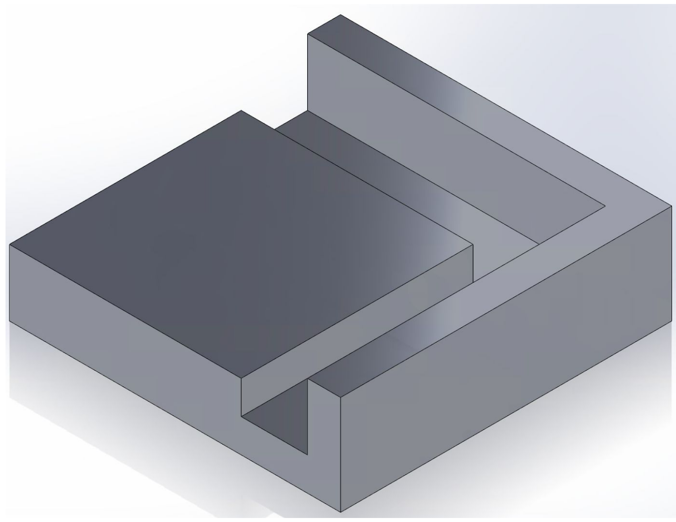

Figure 3: *Solidworks model for the Base of the motion sensor mount*

For the final protoboard, the component will be placed in between every other printer since each board can receive input from two motion sensors at a time. Also, these cases will no longer be made of PLA, and will no longer be placed underneath the 3D printers. First, after a short test to see if the PLA could withstand the heat generated by the printers, a small piece which was meant to be used as a cover, no longer acted like a plastic and deformed to form an arc. Over longer periods, the team worries that this cover could melt onto the protoboard, effectively ruining it. To prevent this the team decided to move to MDF which does not melt at the same temperatures as plastic. Next, the team moved the case in between the printers for two reasons. First, the wires passing in between two printers in order to support the second motion sensor would be too long and too obtrusive. Secondly, the heat generated by the printer could affect the components on the protoboard and cause unintended errors in the system. After this decision, we chose to follow through using MDF since it was more appealing and was used for other cases throughout the facility.

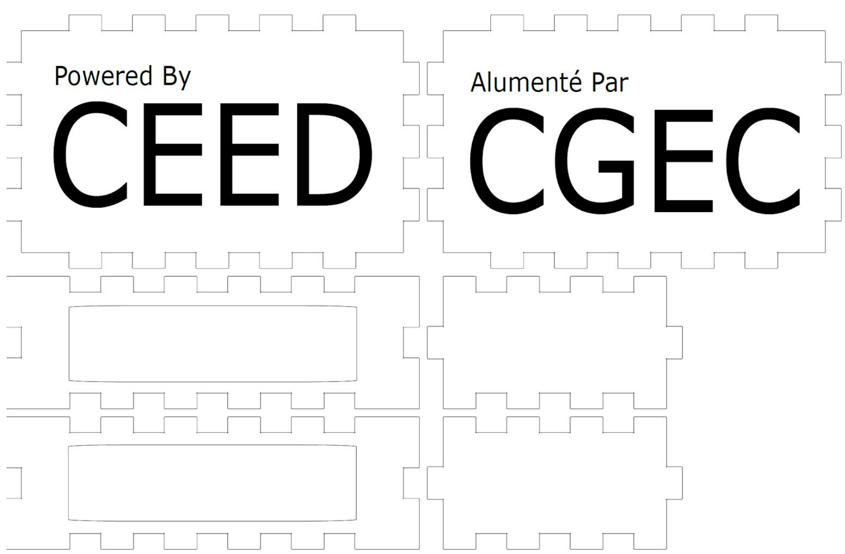

Figure 4: *Vector for proto board case*

Test Plan

Motion sensor

Motion sensor is the only data source in the system. The sensor should be able to detect the motion of 3D printer lever in a reasonable distance with negligible delay. In which sense, the sensor can fail in the following ways:

1. Fail to detect the motion due to improper placement
2. Detected the motion unintentionally (ie. people passing by)
3. Having a long delay
4. Sensor breakdown

Any of the above can lead to inaccuracy. To improve the consistency of the system, we plan to conduct tests. During testng, we will use focused and physical prototypes because we only interested in the sensor and we don't have any formula to calculate sensor functionality.

The sensor has its detecting range. The range does not always benefit the functionality of the system; it will receive extra noise if the range is too large and it may fail to detect if the range is too short. To test the placement, the process is listed:

Nov 20th:

1. Connected the motion sensor to NodeMCU
2. Running the code and have the sensor ready to work
3. Turn on the 3D printer
4. Place the sensor at a preferred location (ie.10 ,20 or 30 centimetres away from sensor)
5. Test if the sensor can detect the motion
6. Adjust the sensitivity if the sensor fail to detect
7. If the sensor works well,then we are done. Otherwise restart from step 4.

In the IDE coding, we designed a buffer to prevent any unintentionally motion. The coding involves some variables such as detecting interval and buffer capacity. To find a more efficient value for these variables, the testing process is listed:

Nov 21st:

1. Connected the motion sensor to NodeMCU
2. Running the code and have the sensor ready to work
3. Turn on the 3D printer
4. Place the sensor at an effective location
5. Watch the printing process. Record how often the system fails to determine the state.
6. Do the same when the printer is off. Record how often the system fails to determine the state.
7. If the system always fails, then increase the buffer capacity and decrease the detection interval and vice versa.

8. Adjust the value until the fail rate (failure times divided by total measuring times) lower than 10%

The team is not planning to do any durable test on motion sensor. We can get the data from manufacturer. Also, we do not have the budget to replace a motion sensor if it is damaged during testing.

PLA Case for Hardware

November 20th:

The purpose of this test was to analyse the heat resistance of the PLA; how long it could resist the heat and how much heat it could withstand.

1. Low Stress Environment
    a. Place Components individually underneath the 3D printer
    b. Analyse the rigidity from before and after
    c. Determine if the components have deformed due to the heat
2. High Stress Environment
    a. Place components individually onto 8x10” paper
    b. Heat the components using a hair dryer for up to an hour
        i. If these components can survive an hour then they should withstand the heat from the printer
        ii. If they fail this test, then the team cannot be certain about their ability to withstand the heat.
    c. If the components can be removed from the paper then they have not melted beyond the failure point

When performing the low stress test, the top of the case began to melt resulting in a piece that began to bend and deform when removed from underneath the printer. This test was performed for only three hours. However, the maximum a print can take is approximately eight hours, on days where the makerspace opens at 10 AM and closes at 6 PM. If this test had been performed for longer, it is suspected that the pieces would have begun to actually melt, and in a real scenario would have damaged the components it was designed to protect.

For the high stress test, the components began to visibly melt after only ten minutes, and at the end of the test they could not easily be removed from the paper. While this scenario is a less accurate simulation of what would really happen, it forced the group to move to a different material for protecting the components.

Conclusion

In summary, the final version of the prototype for the software system are in place and the hardware subsystem are finalizing the mounts and putting them into place for the prototype being put on display for design day. As well, the performance test cases for the motion sensor have been documented and the durability tests for the PLA cases have been conducted and the steps recorded for reference later on.